PROJECT PLAN PROSPECTUS
206 Manure and Byproduct Utilization
December 2004 – February 2005

Management Research Unit

5438-05-40 – Nutrition Research Unit

Old CRIS Project Number

5438-31000-053-00D

Location

Clay Center, Nebraska

Title

Conservation of Manure Nutrients and Odor Reduction in Swine and Cattle Confinement Facilities

Scientists

Vincent H. Varel, Lead Scientist..... 1.0%
Daniel N. Miller..... 1.0%

Total Scientific Staff Years

2.00

Planned Duration

60 months

Signatures

Calvin L. Ferrell /s/	06/24/2004
Research Leader	Date Approved
Steven M. Kappes /s/	06/29/2004
Center Director	Date Approved
Eric E. Roos /s/	07/06/2004
Area Director	Date Approved
Robert J. Wright /s/	8/4/2004
National Program Team Leader	Date Approved

Key Words

Manure, Cattle, Swine, Odor, Nutrients, Microorganisms, Pathogens

Objectives

Objective 1: Determine the influences of diet composition on odor compound, nitrogen, and greenhouse gas emission from manure in beef cattle and swine confinement facilities.

Objective 2: Define the beef cattle feedlot surface conditions affecting microbial activities that minimize the environmental impact of animal manure.

Objective 3: Develop strategies and technologies to reduce ammonia and odor emissions from beef cattle and swine confinement facilities.

Need for Research

* *Description of the Problem to be Solved* - Livestock production has become more concentrated, which increases the risk for manure-related environmental pollution (i.e., nutrient mobilization, greenhouse gases, ammonia emissions, and odors). Microbial activities are responsible for a majority of the negative manure-related environmental issues, however some microbial activities are beneficial and should, if possible, be stimulated. Regardless of the microbial process, basic information about the rates and limits of microbial activities in manure environments is inadequate to explain observed patterns in emissions, let alone to predict and control emissions. A cattle feedlot surface and a deep-pit swine basin are individual ecosystems, each containing hundreds of microbial species which produce over 200 chemical compounds that contribute to odor. Odor is subjective, undefined, and there are no standard methods to quantify it. The lack of basic information on manure microbial processes hampers research efforts focused on assessing and controlling emissions from confined animal production sites.

* *Relevance to ARS National Program Action Plan - Manure and Byproduct Utilization* – The information obtained from this research program will support products and outcomes described in Component 1 (Atmospheric Emissions) of NP 206 with emphasis in Focus Area 1 (Understanding the Biological, Chemical, and Physical Mechanisms Affecting Emissions) and Focus Area 3 (Control Technologies and Strategies for Emissions).

* *Potential Benefits Expected from Attaining Objectives* – Ultimately, producers, the rural communities impacted by manure emissions, scientists, and the general public will benefit from this program by utilizing the information on the critical control factors regulating microbial activities in manure environments to develop better management tools and technologies to reduce the environmental impact of modern livestock production.

* *Anticipated Products of the Research* – New chemical additives, improved feeding and management strategies to reduce nutrient and odor emissions from cattle and swine production facilities are the expected products. Fact sheets will be produced describing recommended additive application and efficacy, the effects of common diets on manure composition and

subsequent odor and nutrient emissions, and feedlot surface management strategies to minimize the environmental impact related to microbial activity.

* *Customers of the Research and Their Involvement* - Livestock manures have many chemical and biological similarities, therefore, stakeholders involved in cattle and swine production should benefit from this work. Extension and private sector consultants will be able to provide information on the environmental conditions and management practices (including diet and the use of chemical additives) affecting potential manure microbial activities to producers in order to minimize the environmental impact of animal production. Scientists and regulators should also benefit from the information relating to the microbial factors affecting odor and nutrient emission to develop better process based emission models.

Scientific Background

This project is closely coordinated with projects in the Nutrition Research Unit (CRIS 5438-31000-021, “Prevention of Zoonotic Pathogen Transmission from Animal Manure to Human Food”; CRIS 5438-31000-075, “Strategic Feeding to Optimize Nutrient Use and Reduce Environmental Impact of Cattle and Sheep”; CRIS 5438-31000-078, “Strategies to Improve Efficiency of Nutrient Use and Minimize Nutrient Excretion by Swine”) and the Biological Engineering Research Unit (CRIS 5438-63000-008, “Management of Nutrients Impacting the Environment from Beef Feedlots”) at the U.S. Meat Animal Research Center in Clay Center, Nebraska. This project is also in collaboration with EcoSmart Technologies, Franklin, TN under a memorandum of understanding (Agreement #58-5438-3M-676). Complementary, yet distinctive, CRIS research projects focusing on the microbiology of animal manures are being conducted at the Swine Odor and Manure Management Research Unit (CRIS 3625-31000-002, “Reduction of Swine Production Odor Through Nutrition and Microbiology”) at the National Soil Tilth Research Laboratory in Ames, Iowa and at the Fermentation Biochemistry Research Unit (CRIS 3620-63000-002, “Developing Anaerobic Microbiological Processes for Swine Waste Management”) at the National Center for Agricultural Utilization Research in Peoria, Illinois. This project also collaborates with two research projects (CRIS 6209-12310-002-00, “Integrated Management Regimens That Minimize the Environmental Impact of Livestock Manure”; CRIS 6209-12310-002-07, “Influence of Protein and Phosphorus Nutrition of Beef Calves on Metabolism and Ammonia Emissions”) at the Conservation and Production Research Laboratory at Bushland, TX.

Approach and Research Procedures

Objective 1. Determine the influences of diet composition on odor compound, nitrogen, and greenhouse gas emission from manure in beef cattle and swine confinement facilities.
Hypothesis: Starch, non starch carbohydrate, and protein excretion in manure differ by diet, and these compounds are differentially utilized by microorganisms to produce malodorous compounds, ammonia, and greenhouse gases.

Experimental design: Manure from diets differing in starch, fiber, crude protein, and distiller’s byproducts content or source will be evaluated in order to determine diet effect on (i) odor compound production and emission, (ii) nitrogen transformation and loss, and (iii) greenhouse gas emission. Manure slurries and semi-solid states will be incubated over time at ambient temperature and analyzed for microbial end-product formation including straight and branched

chain volatile fatty acids, aromatic, sulfur-containing, and nitrogenous compounds, alcohols, and the greenhouse gases--methane, carbon dioxide, and nitrous oxide. Products will be determined in the liquid/solid content and from gas samples emitted, and analyzed using gas chromatography-mass spectroscopy. Typical production diets will be evaluated at laboratory and field levels in collaboration with nutritionists (Drs. Ferrell, Freetly, Klindt, Yen, Erickson, and Cole), microbiologists specializing in pathogenic microorganisms (Drs. Berry, Wells, Rice, and Purdy), and engineers (Drs. Woodbury, Eigenberg, Nienaber, Schulte, and Koelsch) in order to obtain systems-level information on animal performance and emissions (ammonia, odor, greenhouse gases, pathogens, and dust). Manure incubation conditions will simulate cattle feedlot surface and swine deep-pit basins.

Contingencies: Appropriate incubation, emission measurement, and analysis methods will be implemented as they become available. Additional swine and beef cattle diets can be evaluated based upon changes in industry practices.

Objective 2. Define the beef cattle feedlot surface conditions affecting microbial activities that minimize the environmental impact of animal manure. *Hypothesis:* Moisture content, ratio of manure to soil, and temperature of the feedlot surface are the dominant factors that contribute to an anaerobic microbial environment on the feedlot surface, which produces more offensive odor compounds, enhances detrimental nitrogen transformations, and contributes to greater greenhouse gas production than an inactive or aerobic microbial state.

Experimental design: Environmental conditions that determine one of three microbial physiologies (inactive, aerobic, and anaerobic) will be evaluated in multiple manure and soil incubations varying the manure moisture content, manure to soil content, and temperature. Percent moisture (10 to 60%) and manure content relative to soil (5, 25, and 75%) will initially be evaluated with laboratory studies in order to determine their effect on the microorganisms responsible for odor compound production, nitrogen transformation, and greenhouse gas production in livestock manure environments. Once microbial states are defined based upon manure and moisture content, each state will be further evaluated along a continuum of temperatures (5 to 40 degrees Celsius) and under fluctuating moisture conditions (cycles of 60% to 10% moisture) in order to define the feedlot surface conditions that yield minimum environmental impact. Pathogen enumeration will be conducted in collaboration with Drs. Berry and Wells, whereas incubations in temperature-controlled chambers will be conducted in collaboration with Drs. Woodbury and Nienaber.

Contingencies: Improved incubation, emission measurement, and analysis methods will be adopted as needed. Other feedlot surface environmental conditions (manure from differing diets, soil types from different cattle-producing regions) can be evaluated.

Objective 3. Develop strategies and technologies to reduce ammonia and odor emissions from beef cattle and swine confinement facilities. *Hypothesis:* A combination of plant essential oils and urease inhibitors will limit microbial activities that lead to odor compound production, ammonia formation, and greenhouse gas emissions.

Experimental design: A variety of environmentally amiable compounds including bacteriostatic, bacteriocidal, and other microbial and enzymatic inhibitors will be evaluated for their ability to control odor production, limit greenhouse gas emissions, and reduce nutrient loss from livestock

manures. Previous work with antimicrobial oils indicates they are effective in controlling odor production; however, they are volatile when topically applied to a feedlot surface. Similarly, urease inhibitors on a feedlot surface are vulnerable to rapid degradation unless a slow-release mechanism is developed. Corncobs are an effective granule; however, they have limited carrying capacity for plant oils and logistically were bulky when applied. Initially laboratory studies will be conducted to define at what concentrations both of the additives can be incorporated into commercial slow-release granules and serve as an effective control for pathogens, odor, ammonia, and gas emissions. The optimized concentration from the laboratory studies will be evaluated on feedlot surfaces to determine if the laboratory results can be duplicated at a field scale. A similar approach without the granule will be evaluated in deep-pit swine production field trials. Private sector collaborations with Drs. Sutton, Cardenas, and Dongieux will be used to produce antimicrobial granules. Field evaluation will involve collaborations with Drs. Berry and Wells. Additive application within cattle feedlot pens will be influenced by the findings obtained in Objectives 1 and 2, and a cost estimate will be determined on a per animal basis.

Contingencies: If the phenolic compounds are not compatible with the urease inhibitor in a granule, other aldehyde or alcohol compounds of plant oils and their combinations can be evaluated. Similarly, additional promising microbial inhibitors identified from an overall review in this area can be evaluated.

Collaborators

ARS - Calvin Ferrell, Elaine Berry, Harvey Freetly, John Klindt, James Wells, J-T Yen, Bryan Woodbury, Roger Eigenberg, and John Nienaber at Clay Center, NE will be required for expertise and access. Noel Cole, William Rice, and Charles Purdy at Bushland, TX will also be required for expertise and access. Outside ARS - Galen Erickson, Dennis Schulte, Richard Koelsch, and other faculty at the University of Nebraska, Lincoln, NE will be required for expertise and access. From private sector and industry - Allen Sutton at Agrotain International (St. Louis, MO), Carlos Cardenas at Millennium Chemicals (Jacksonville, FL), and Paul Dongieux at Kadant GranTek Incorporated (Granger, IN) will also be required for collaborative research.

Conflicts of Interest- See attached list which covers all scientists included on this project.